SCIENTOMETRIC PORTRAIT OF BHARAT RATNA PROFESSOR C N R RAO : A STUDY

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Abstract

The article explores the scientometric assessment of research output of Professor C N R Rao's publications during the period from 1954 to 2013. Out of his total publication, 1521 research papers are analyzed. A scientometric assessment of the status of his research papers are presented in this study by analyzing Year-wise distribution of publications, authorship pattern, collaborative research pattern, highly preferred journals, highly impact factored journals, highly preferred publishers, highly cited papers etc. These publications have been taken from Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore with an average publication of 25.77 articles per year. The study reveals that highest number of papers are published in collaborative nature and published in foreign journals. This study is certainly useful for experts, analysts, research scholars, professionals and policy makers on the basis of inferences drawn in this paper.

Introduction:

Qualitative documentation performance of an individual scientist or author has wide impacts in the field of scientometrics. A scientometric portrait deals with quantitative documentation of the communication of science by scientists. Scientific publications reflect total contribution of a scientist in his respective domain[1]. Scientometric is the study of the qualitative aspects of science based on scientific or statistical activities[2].

After Dr. C V Raman and former President A P J Abdul Kalam, Professor Chintamani Nagesa Ramachandra Rao (CNR Rao) is the third scientist to be awarded the highest civilian award Bharat Ratna, a crowning glory of his inexorable list of outstanding achievements. Prof. C.N.R. Rao is the National Research Professor (NRP) as well as Honorary President and Linus Pauling Research Professor at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCAS),

Delhi. He is also an Honorary Professor at the Indian Institute of Science. Solid state and materials are the main research interests of Dr. Rao. chemistry.

He has authored over 1600 research papers and 50 books. He received masters degree (M.Sc.) from BHU, Ph.D. from Purdue university, D.Sc. from Mysore university and has received honoris causa doctorate degrees from 53 universities including Banaras, Delhi, Mysore, IIT Bombay, IIT Kharagpur, Northwestern, Purdue, Bordeaux, Notre Dame, Novosibirsk, Oxford, Grenoble, Uppsala, Wales, Stellenbosch, Wroclaw, Caen, Khartoum, Calcutta, Visva-Bharati and Sri Venkateswara University.

Dr. Rao is a Member of the Foreign Fellow of the Royal Society of Canada, Pontifical Academy of Sciences, and Foreign Member of Academia Europaea. He is one of the members of editorial boards of several leading professional journals and is a distinguished visiting professor of the University of California and Cambridge University. He is a member of major science academies in the world including Royal Society, London, the National Academy of Sciences, U.S.A., the Russian Academy of Sciences, French Academy of Sciences, Japan Academy as well as the Polish, Czechoslovakian, Serbian, Slovenian, Brazil, Spanish, Korean and African Academies and the American Philosophical Society.

Among the various medals, honours and awards received by him, some of those are Marlow Medal of the Faraday Society (1967), Bhatnagar Prize (1968), Padma Shri (1974), Centennial Foreign Fellowship of the American Chemical Society (1976), Royal Society of Chemistry (London) Medal (1981), Padma Vibhushan (1985), Honorary Fellowship of the Royal Society of Chemistry, London (1989), Hevrovsky Gold Medal of the Czechoslovak Academy (1989), Blackett Lectureship of the Royal Society (1991), Einstein Gold Medal of UNESCO (1996), Linnett Professorship of the University of Cambridge (1998), Centenary Medal of the Royal Society of Chemistry, London (2000), the Hughes Medal of the Royal Society, London, for original discovery in physical sciences (2000), Karnataka Ratna (2001) by the Karnataka Government, the Order of Scientific Merit (Grand-Cross) from the President of Brazil (2002), Gauss Professorship of Germany (2003) and the Somiya Award of the International Union of Materials Research (2004). He is the first recipient of the India Science Award by the

Government of India and received the Dan David Prize for science in the future dimension for his research in Materials Science in 2005. He was named as Chemical Pioneer by the American Institute of Chemists (2005), Chevalier de la Légion d'Honneur by the President of the French Republic (2005) and received the Honorary Fellowship of the Institute of Physics, London (2006) and St. Catherine's College, Oxford (2007). He received the Nikkei Asia Prize for Science, Technology and Innovation (2008). He was awarded the Royal Medal by the Royal Society (2009) and the August-Wilhelm-von-Hoffmann Medal for his outstanding contributions to chemistry by the German Chemical Society (2010). He received the Ernesto Illy Trieste Science Prize for materials research in 2011.

Prof. Rao is a Chairman of Scientific Advisory Council to the Prime Minister, former president of The Academy of Sciences for the Developing World (TWAS) and Member of the Atomic Energy Commission of India.

He is a Founder-President of both the Chemical Research Society of India and of the Materials Research Society of India. Prof. Rao was President of the Indian National Science Academy from 1985 to 1986, the Indian Academy of Sciences from 1989 to 1991, the International Union of Pure and Applied Chemistry from 1985 to 1997. He was the Director of the Indian Institute of Science from 1984 to 1994, Chairman of the Science Advisory Council to Prime Minister Rajiv Gandhi from 1985 to 1989 and Chairman, Scientific Advisory Committee to the Union Cabinet from 1997 to 1998 and Albert Einstein Research Professor from 1995 to 1999[3].

Objectives of the study:

The main objectives of the present study are to analyze the broad characteristic features of research output of Professor C N R Rao's publications during the period from 1975 to 2013 using quantitative and qualitative indicators:

- To identify year-wise growth of publication;
- To identify authorship pattern, collaborative research pattern of Dr. C.N.R. Rao research ;
- To identify highly preferred journal, highly impact factor journal;
- To identify highly preferred publisher in their respective research work;

- To identify and compare research output in terms of the number of citations received, and their importance in present scenario;

Methodology:

Scientific portrait is the best source to measure the growth of publication of an individual scientist in a particular discipline. The data collected for the present study have been taken from Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore in the month of Mar 2015. CNR Rao published 1604 papers during 1954-2013 which include articles, conference papers, editorials, letters, meeting papers and book chapters which are available in the above mentioned research institute. In this paper only 1521 research articles of C N R Rao have been taken for study. MS-Excel tool was used for data tabulation, analysis and preparing relevant charts through Origin8 software. Citations for the research papers in this study were examined from Google Scholar website during the period from 1954 to 2013 till March 2015. The results were analyzed and tabulated as mentioned above in the objective of this paper.

Review of literature:

Various studies have been conducted in the past on the scientometric studies of an individual scientist. This includes publication productivity, collaboration and authorship trend of several eminent scientist of past and present. Quantitative and qualitative study of publication productivity of individual scientist with graphical representation facilitates clear perception of the scientist[4].

Mukharjee studied paper titled "A scientometric profile of Prof. Lalji Singh as seen through web of science and scopus". He found during his study that he published 222 papers which indicate that his productivity increased from the year 2000 onwards.

The percentage of collaborative work of the scientist was found to be very high as he published 98% of his total papers with 805 collaborators with whom he worked in various organizations. His papers have been scattered in 113 scientific journals, out of which 62 journals are having impact factor more than 2[4].

Munnolli, S.S. and Kalyane, V.L. studied "scientometric portrait of Ram Gopal Rastogi". Their observations found that he has published 312 papers during 1954 to 1992 in various domains.

His highest productivity was in the year 1978 with 28 papers followed by 19 papers in 1977. He collaborated with 97 scientists during 1954 to 1990[5].

Another study of Munnolli, S.S., Pujar, S.M. and Kademani studied "scientometric portrait of nobel laureate Harald Zur Hausen". They found that Herald zur Hausen has published 285 papers with average of 6.19 papers per year during his 46 years of research tenure. The number of co-author was 373 with whom he guided as mentor and collaborated in the multi-disciplinary nature of subjects he addressed during his scientific career[6].

Hazarika, T., Sarma, D. and Sen, B.K. studied "scientometric portrait of Nayna Nanda Borthakur: a biometrologist". They found that he published 106 research papers during 1963 to 2005. Two and three authored papers constitute nearly 57% of the total authorship of his papers while single author papers are nearly 10% of the total authorship[1].

V. Kalaiappan, K. kaliyaperumal and V. Rajasekar studied "Scientometric analysis of literature output of Prof. G.N. Ramachandran in the subject of biophysics and crystallography".

They found during study that 35.51% of the total contribution was solo research. Authorship collaboration ratio 1.00:1.51 indicates that collaboration is higher than the individual publications. He published highest number of research papers in the year 1963 with 13 publications and 12 research paper published in 1966. Average number of research papers published was 4 to 5 per year. Peek productivity of Prof. Ramchandran was during 1962 to 1971[7].

Satish Kumar, H.T., Keshava and Gautam, J.N. studied "A scientometric portrait of Swarn Jeet Singh (SJS) flora". They found Flora published 280 papers during 1981 to 2008 with an average of 10 research papers per year. His highest publication was 21 in the year 2005. An exponential growth in number of publication was observed during 1981 to 2008. The highest growth rate 45% was recorded during 2001 to 2004 with 58 publications followed by 66 (17.79%) publication during 2005 to 2008. S.J.S. flora has collaborated with 103 researchers[8].

Zafrunnisha, N. studied "Bradford's zones and productivity of journals in psychology doctoral theses". He has found the average rate of productivity of journals in the first group is 254 articles, whereas it has considerably gone down to 10.73 articles in the fourth group. The journal distribution as per the Bradford's law reveals the ratio as 17:46:358 in psychology[9].

Jain, Keerti Bala and Kumar, S. studied "Indian contribution to world soybean research: measurement of research productivity of soybean scientist". They found during their study that India rank 2nd in total number of research publications with 13.64% share in the world.

The activity index of India decreases gradually. The growth rate has also decrease gradually and correspondingly doubling time has increased. Out of the total papers based on this study reveals that 93.10% has been authored by co-authors. The average collaboration coefficient is 0.931 and average collaboration index value is 3.115[10].

Singh, K.P. and Bebi studied "application of Bradford's law on journal citation: a study of Ph.D. theses in social sciences of university of Delhi". They covered 260 Ph.D. theses submitted during 1995 to 2008 which includes 9,997 references scattered in 934 journals for this study. Their study found that 22.8% citations was from economic and political weekly followed by the Punjab past and present with 1.80% citations[11].

Nagarkar, Shubhada studied "a bibliometric analysis of publication of the chemistry department, university of Pune, India, 1999 to 2012". This study data reveals that thirty faculty members have published 811 papers in 258 journals with 8948 citations. More of the papers are published in peer reviewed international journals having high impact factor. The study reveals that there is a continuous growth in publication. About 30% of the papers were published during 2010 to 2012. The average number of citations received per paper is 11.03. The highest number of citations for 41 papers published in the journals of physical chemistry was 905. This study indicates that majority of the papers published are in the area of physical chemistry[12].

Results:

Productivity Pattern: C.N.R. Rao has published 1521 research papers during 1954 to 2013 in his 59 years of professional career. Out of these 1521 papers he has published 60 numbers of papers with single authorship, 269 papers with two authorship, 497 with three authorship and so on. Papers with three authors have maximum percentage of 32.67 and with twelve authors has minimum percentage of 0.06. His research team published total 1521 papers with the contribution of total 5416 authors (Table 1 and Fig.1).

Table 2 and Fig. 2 shows Country wise distribution of papers Rao has published 15 different countries in his career. Out of 1521 research papers that he has published, 497 research papers have been published in USA which is approximately 32.67 % of the total papers. UK and

Netherlands follow suit with number of papers 444 and 267 respectively which is 29.19 % and 17.55 % of the total papers that he has published. India comes fourth with 107 numbers of papers. Poland and Sweden rank last with single paper published from both the countries.

Figure 3 shows relation between year wise growth pattern of author productivity and growth rate of publication. Highest growth is 1600 in the year 1966.

Collaboration Pattern:

Figure 4 clearly state that different type of growth rate in the block years. Highest growth rate as a single and main author is 38.33% and 28.68% respectively for the year 1985 to 1994. Highest growth rate in terms of number of papers published as Co-author and total number of paper published as single and co-author both 28.26% and 27.15% respectively for the year 1995 to 2004.

Table 3 reflects that CNR Rao has published 54 papers at the age of 46 in the year 2000 which is highest year wise. From 2001 to 2003 he has published 47 research papers yearly which are second highest in the list of papers published year wise.

He has published seven researches with single authorship in the year 1988. Highest number of papers that he has published with co-authorship is 53 in the year 2000.Highest number of papers published with co-authorship in which he is first author is12 in the year 1988.

Table 4 shows most prominent co-authors associated with C N R Rao. The most active co-author is Govindaraj, A. who topped the list with 141 (9.27 percent) research papers followed by Kulkarni, G.U. , Natrajan, S., Ganguli, P. , Cheetam, A.K. and Sood, S.K. with 77(5.06%) ,62(4.07%),55(3.62%),54 (3.55%)and 51(3.35%) research papers respectively.

Channels Pattern:

Table 5 clearly shows different journals in which CNR Rao has published his research papers. Rao has published his papers in 216 journals. Contribution of top 10 journals is 34.65 percent of the total number of publications. Highest paper published by him is 93 in the Journal of Solid State Chemistry which is published by Elsevier followed by Chemical Physics Letters (Elsevier), Solid State Communications (Elsevier) with 92 and 66 papers respectively and so on.

Table 6 covers the papers published by CNR Rao in journals with high impact factors in 2013. He has published 2 papers in Chemical Reviews (ACS) with highest impact factor of 45.661 followed by Nature (6 papers), Nature Materials (1 papers), Science (4 papers) and Chemical

Society Reviews (RSC) (6 papers) with impact factors of 42.351, 36.425, 31.48 and 30.425 respectively.

Citation Pattern:

Table 7 and 8 covers the annual growth of publication and its citations. Highest growth of paper published by CNR Rao is 1600 in the year 1966 which followed by annual growth rate of 266.66 and 133.33 in the 1957 and 1979 respectively. Total citation for his research papers is 64634. Highest number of citations for his research papers is 4798 citations in the year 2009 which if followed by 4116 and 3496 research papers in the year 1997 and 1996 respectively. The title "Graphene: A new two dimensional nonmaterial's" in the journal "Angewandte chemie International Edition" published by

Wiley in the year 2009 received 1785 citation which is followed by "Metal carboxylates with open architectures" and "Inorganic nanowires" received 1704 and 725 citations in the year 2004 and 2003 respectively.

Publisher Pattern:

Table 9 clearly shows publisher wise distribution of his papers. Rao has published his papers in 217 journals covering 41 publishers. Highest paper published by him is 563 in 63 different journals published by Elsevier (Science Direct) which is followed by Royal Society of Chemistry (RSC) and American Chemical Society (ACS) with 23 and 20 journals and 203 and 169 papers respectively and so on.

Author Wise Distribution of papers

S. No.	Number of Author	Number of Papers	% of Papers	Number of Authors	% of Authors
1	One	60	3.94	60	1.11
2	Two	269	17.68	538	9.93

3	Three	497	32.67	1491	27.52
4	Four	379	24.92	1516	27.99
5	Five	194	12.75	970	17.91
6	Six	68	4.47	408	7.53
7	Seven	28	1.84	196	3.62
8	Eight	11	0.72	88	1.62
9	Nine	6	0.39	54	0.99
10	Ten	5	0.32	50	0.92
11	Eleven	3	0.19	33	0.6
12	Twelve	1	0.06	12	0.22
Total		1521	99.95	5416	99.96

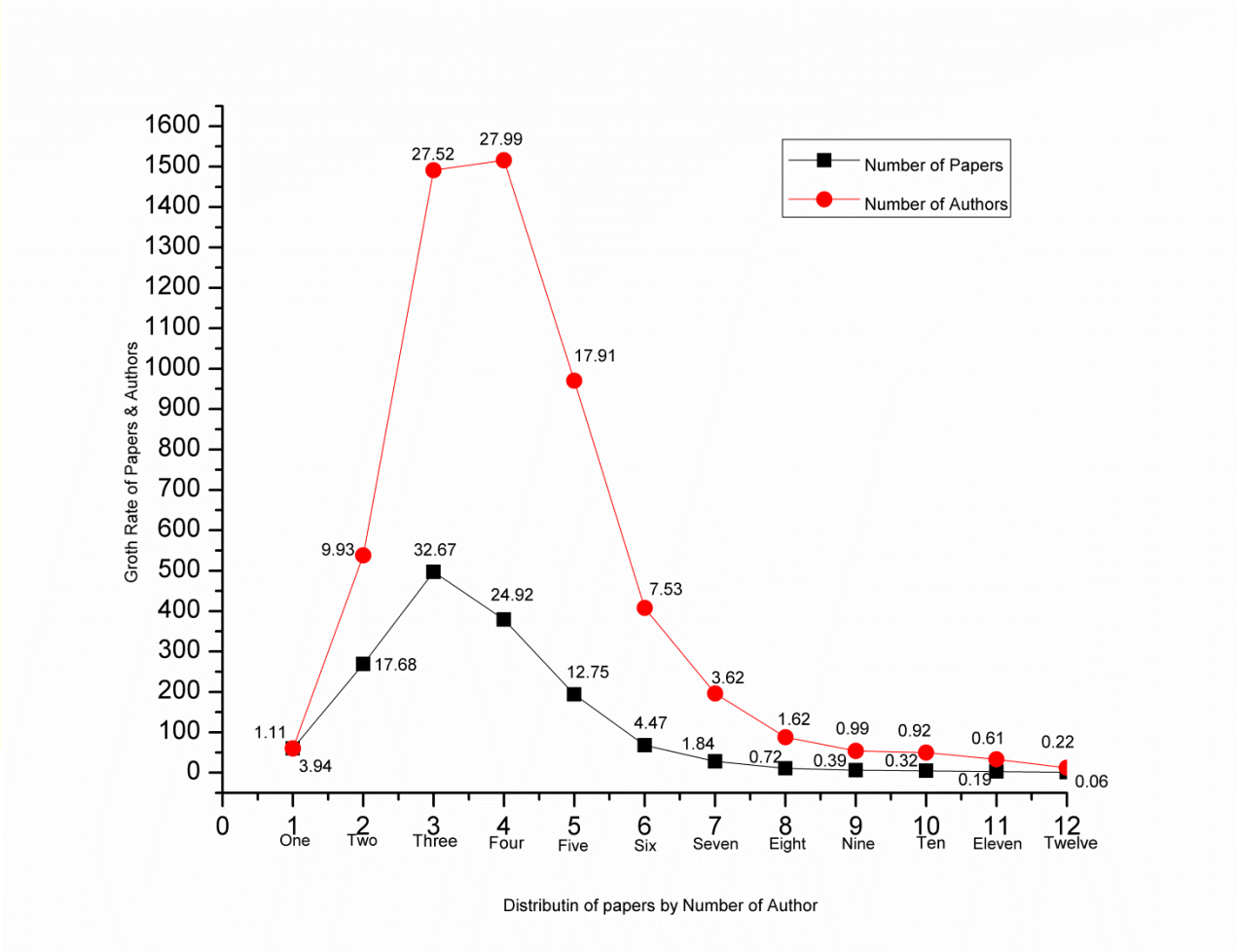
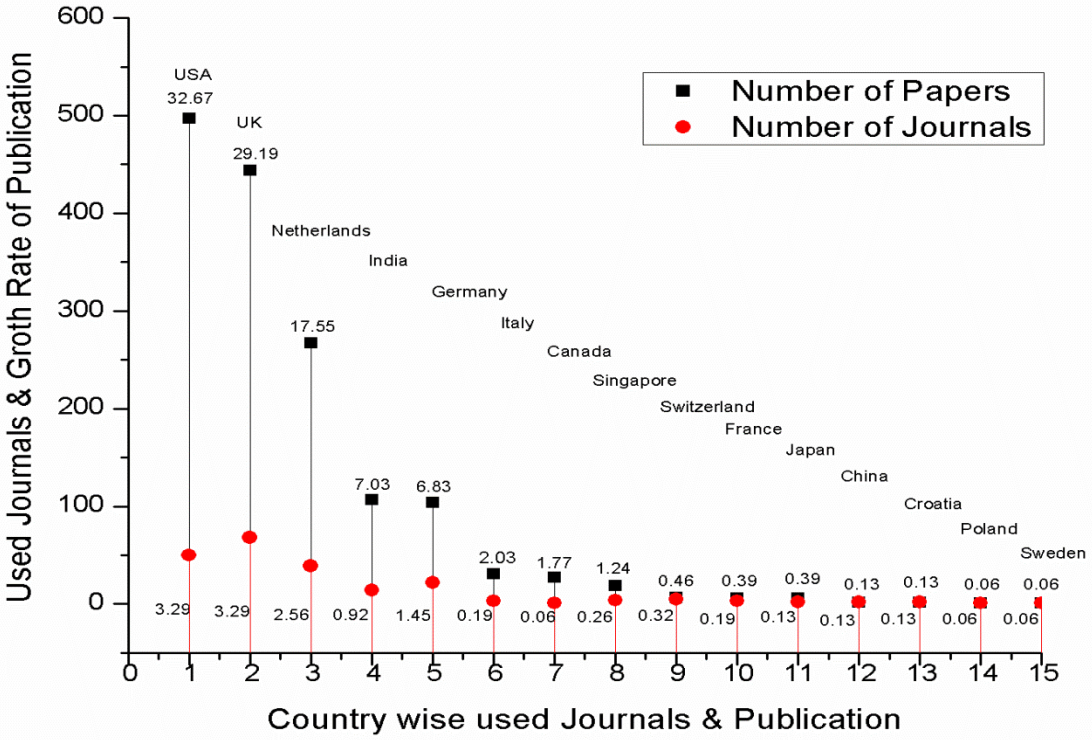


Fig.1

Country wise distribution of papers

S. No.	Country	No of Papers	% of Countries in the Total Publication	Country Wise Used No. of Journals	% of Journals Used in the the Research Period
1	USA	497	32.67	50	23.04
2	UK	444	29.19	68	31.34
3	Netherlands	267	17.55	39	17.97
4	India	107	7.03	14	6.45
5	Germany	104	6.83	22	10.13
6	Italy	31	2.03	3	1.38
7	Canada	27	1.77	1	0.46
8	Singapore	19	1.24	4	1.84
9	Switzerland	7	0.46	5	2.3
10	France	6	0.39	3	1.38
11	Japan	6	0.39	2	0.92
12	China	2	0.13	2	0.92
13	Croatia	2	0.13	2	0.92
14	Poland	1	0.06	1	0.46
15	Sweden	1	0.06	1	0.46
Total		1521	99.93	217	99.97

Fig.2


Used Journals & Groth Rate of Publication
Country wise used Journals & Publication
Number of Papers
Number of Journals
USA
32.67
UK
29.19
Netherlands
17.55
India
7.03
Germany
6.83
Italy
2.03
Canada
1.77
Singapore
1.24
Switzerland
0.46
France
0.39
Japan
0.39
China
0.13
Croatia
0.13
Poland
0.06
Sweden
0.06
3.29
3.29
2.56
0.92
1.45
0.19
0.06
0.26
0.32
0.19
0.13
0.13
0.13
0.06
0.06
0
100
200
300
400
500
600
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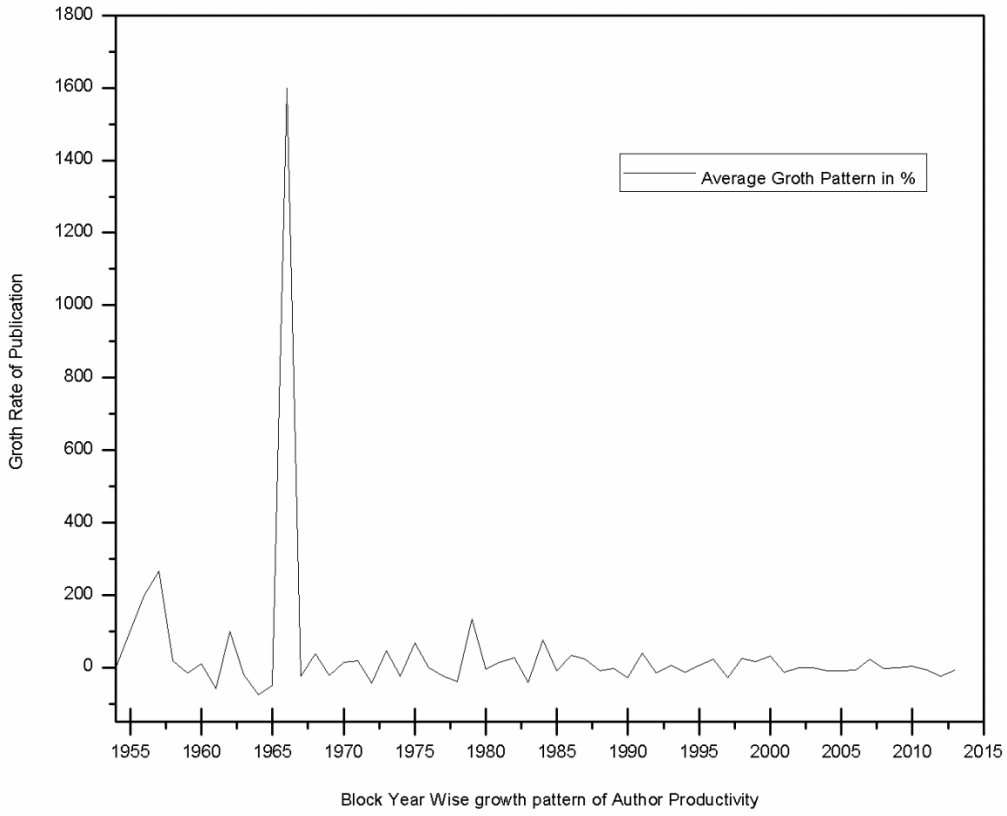
1800
1600
1400
1200
1000
800
600
400
200
0
Groth Rate of Publication
Average Groth Pattern in %
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Block Year Wise growth pattern of Author Productivity

Fig.3

Year Wise Distribution of papers

S.N.	Publication Year	Number of Author		Main Author	Co-Author	Total	Cumulative Total	Collaboration Rate	Age of CNR Rao	Publication Age
		Single Authored	Multi Authored							
1	1954	0	1	0	1	1	1	1	21	1
2	1956	2	1	3	0	3	4	0.33	23	2
3	1957	5	6	6	5	11	15	0.54	24	3
4	1958	2	11	5	8	13	28	0.85	25	4
5	1959	0	11	4	7	11	39	1	26	5
6	1960	1	11	6	6	12	51	0.91	27	6
7	1961	2	3	3	2	5	56	0.6	28	7
8	1962	0	10	3	7	10	66	1	29	8
9	1963	0	8	1	7	8	74	1	30	9
10	1964	0	2	2	0	2	76	1	31	10
11	1965	0	1	0	1	1	77	1	32	11
12	1966	0	17	0	17	17	94	1	33	12
13	1967	0	13	0	13	13	107	1	34	13
14	1968	1	17	4	14	18	125	0.94	35	14
15	1969	1	13	3	11	14	139	0.92	36	15
16	1970	0	16	5	11	16	155	1	37	16
17	1971	0	19	8	11	19	174	1	38	17
18	1972	0	11	0	11	11	185	1	39	18
19	1973	0	16	4	12	16	201	1	40	19
20	1974	1	11	2	10	12	213	0.92	41	20
21	1975	2	18	8	12	20	233	0.9	42	21
22	1976	3	17	7	13	20	253	0.85	43	22
23	1977	0	15	4	11	15	268	1	44	23
24	1978	1	8	2	7	9	277	0.89	45	24
25	1979	0	21	3	18	21	298	1	46	25
26	1980	0	20	4	16	20	318	1	47	26
27	1981	1	22	6	17	23	341	0.96	48	27
28	1982	1	28	7	22	29	370	0.96	49	28
29	1983	0	17	0	17	17	387	1	50	29
30	1984	1	29	6	24	30	417	0.97	51	30
31	1985	5	22	8	19	27	444	0.81	52	31
32	1986	3	33	9	27	36	480	0.92	53	32
33	1987	0	44	11	33	44	524	1	54	33

34	1988	7	33	12	28	40	564	0.82	55	34
35	1989	0	39	7	32	39	603	1	56	35
36	1990	1	27	6	22	28	631	0.96	57	36
37	1991	1	38	6	33	39	670	0.97	58	37
38	1992	0	33	5	28	33	703	1	59	38
39	1993	5	30	9	26	35	738	0.86	60	39
40	1994	1	29	5	25	30	768	0.97	61	40
41	1995	1	31	6	26	32	800	0.97	62	41
42	1996	2	37	8	31	39	839	0.95	63	42
43	1997	1	27	5	23	28	867	0.96	64	43
44	1998	1	34	8	27	35	902	0.97	65	44
45	1999	2	39	2	39	41	943	0.95	66	45
46	2000	1	53	8	46	54	997	0.98	67	46
47	2001	2	45	8	39	47	1044	0.96	68	47
48	2002	0	47	3	44	47	1091	1	69	48
49	2003	1	46	7	40	47	1138	0.98	70	49
50	2004	0	43	5	38	43	1181	1	71	50
51	2005	1	38	4	35	39	1220	0.97	72	51
52	2006	0	36	2	34	36	1256	1	73	52
53	2007	0	44	2	42	44	1300	1	74	53
54	2008	0	43	2	41	43	1343	1	75	54
55	2009	0	43	5	38	43	1386	1	76	55
56	2010	0	41	4	37	41	1427	1	77	56
57	2011	1	37	3	35	38	1465	0.97	78	57
58	2012	0	29	4	25	29	1494	1	79	58
59	2013	0	27	2	25	27	1521	1	80	59
Total		**60**	**1461**	**272**	**1249**	**1521**				
Percent		**3.94**	**96.05**	**17.88**	**82.11**	**100**				

Year Wise Distributin of Publication & Citations

S.No.	Publication Year	Total Published Paper	Annual Growth rate of Paper (%)	Citation by Google Scholar	Average Citation Per Paper (%)
1	1954	1	-	0	0
2	1956	3	200	0	0
3	1957	11	266.66	163	14.82
4	1958	13	18.18	266	20.46
5	1959	11	-15.38	225	20.45
6	1960	12	9.09	198	16.5

7	1961	5	-58.33	134	26.8
8	1962	10	100	372	37.2
9	1963	8	-20	147	18.37
10	1964	2	-75	143	71.5
11	1965	1	-50	50	50
12	1966	17	1600	432	25.41
13	1967	13	-23.53	347	26.69
14	1968	18	38.46	462	25.67
15	1969	14	-22.22	246	17.57
16	1970	16	14.28	491	30.69
17	1971	19	18.75	428	22.52
18	1972	11	-42.28	434	39.45
19	1973	16	45.45	315	19.69
20	1974	12	-25	154	12.83
21	1975	20	66.67	699	34.95
22	1976	20	0	477	23.85
23	1977	15	-25	229	15.27
24	1978	9	-40	63	7
25	1979	21	133.33	561	26.71
26	1980	20	-4.76	633	31.65
27	1981	23	15	385	16.74
28	1982	29	26.08	413	14.24
29	1983	17	-41.37	318	18.71
30	1984	30	76.47	1133	37.77
31	1985	27	-10	526	19.48
32	1986	36	33.33	527	14.64
33	1987	44	22.22	1253	28.48
34	1988	40	-9.09	738	18.45
35	1989	39	-2.5	597	15.31
36	1990	28	-28.2	565	20.18
37	1991	39	39.28	787	20.18
38	1992	33	-15.38	835	25.3
39	1993	35	6.06	726	20.74
40	1994	30	-14.28	537	17.9
41	1995	32	6.66	1304	40.75

42	1996	39	21.87	3193	81.87
43	1997	28	-28.2	3051	108.96
44	1998	35	25	2225	63.57
45	1999	41	17.14	2756	67.22
46	2000	54	31.7	4116	76.22
47	2001	47	-12.96	3496	74.38
48	2002	47	0	3279	69.76
49	2003	47	0	2696	57.36
50	2004	43	-8.51	3385	78.72
51	2005	39	-9.3	1694	43.43
52	2006	36	-7.69	2746	76.28
53	2007	44	22.22	1785	40.57
54	2008	43	-2.27	2736	63.63
55	2009	43	0	4798	111.58
56	2010	41	4.65	2186	53.31
57	2011	38	-7.31	875	23.03
58	2012	29	-23.68	820	28.27
59	2013	27	-6.89	484	17.92
Total		**1521**	**2229.42**	**64634**	**2101**

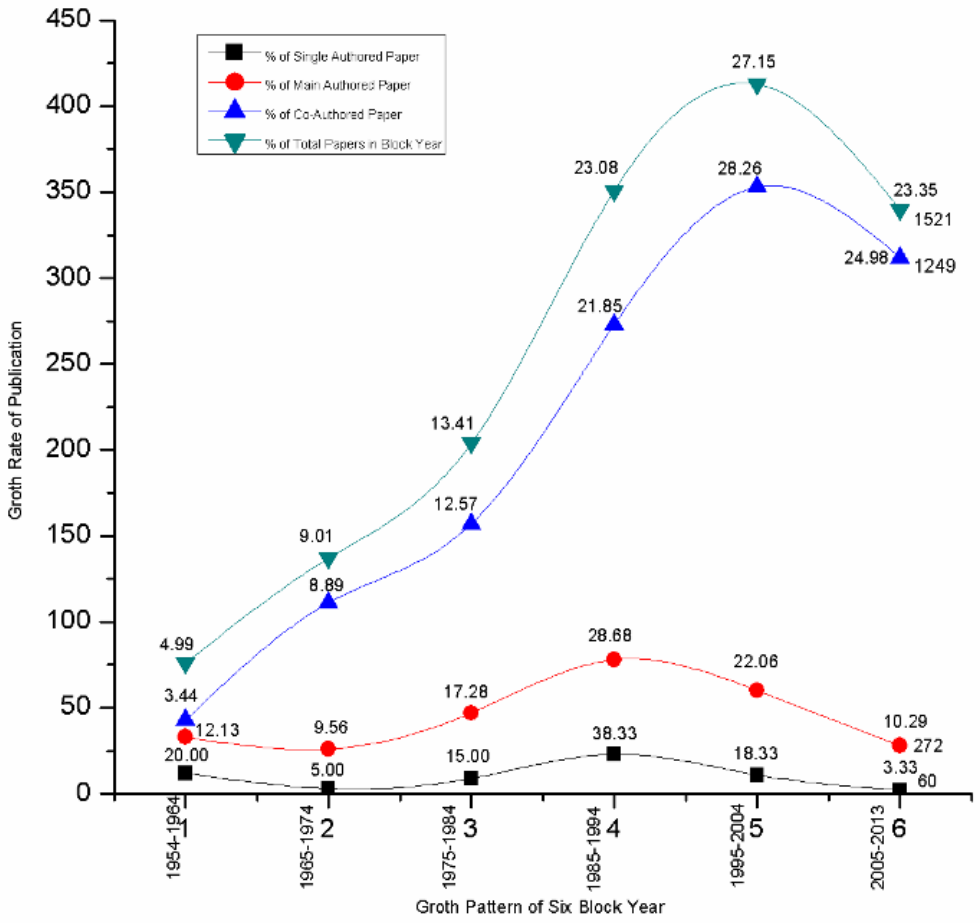
% of Single Authored Paper
% of Main Authored Paper
% of Co-Authored Paper
% of Total Papers in Block Year
Groth Rate of Publication
Groth Pattern of Six Block Year
1954-1964
1965-1974
1975-1984
1985-1994
1995-2004
2005-2013
4.99
9.01
13.41
23.08
27.15
23.35
1521
3.44
8.89
12.57
21.85
28.26
24.98
1249
12.13
9.56
17.28
28.68
22.06
10.29
272
20.00
5.00
15.00
38.33
18.33
3.33
60

Fig.4

Prominent Author Associated with C N R Rao having ≥ 20 Papers

S.No.	Author	FPY	LPY	Total Years	% of Time Expanded in Research	Total Publication	% of Total Publication	% of Co-Auhorship
1	Govindaraj, A.	1992	2013	22	37.28	141	9.27	2.6
2	Kulkarni, G.U.	1989	2003	15	25.42	77	5.06	1.42
3	Natarajan, S.	1997	2004	8	13.55	62	4.07	1.14
4	Ganguly, P.	1973	1989	17	28.81	55	3.62	1.01
5	Cheetham, A.K.	1976	2012	37	62.71	54	3.55	0.99
6	Sood, A.K.	1989	2013	25	42.37	51	3.35	0.94
7	Sarma, D.D.	1979	2013	35	59.32	45	2.96	0.83
8	Raychaudhuri, A.K.	1987	2005	19	32.2	44	2.89	0.81
9	Choudhury, A.	1999	2008	10	16.95	43	2.82	0.79
10	Raju, A.R.	1991	2007	17	28.81	43	2.82	0.79
11	Hegde, M.S.	1978	1994	17	28.81	42	2.76	0.77
12	Sundaresan, A.	2006	2013	8	13.55	42	2.76	0.77
13	Rao, K.J.	1966	1992	25	42.37	36	2.37	0.66
14	Seshadri, R.	1990	2004	15	25.42	36	2.37	0.66
15	Subbanna, G.N.	1983	1997	15	25.42	35	2.3	0.65
16	Gopalakrishnan, J.	1979	2000	22	37.29	34	2.23	0.63
17	Subrahmanyam, K.S.	2008	2013	6	10.17	32	2.1	0.59
18	Neeraj, S.	1999	2004	6	10.17	31	2.03	0.57
19	Vijayaraghavan, R.	1980	1994	15	25.42	30	1.97	0.55
20	Ganguli, A.K.	1986	1996	11	18.64	29	1.9	0.53
21	Matte, H.S.S.R.	2009	2013	5	8.47	28	1.84	0.51
22	Biswas, K.	2006	2013	8	13.55	27	1.77	0.49
23	Nagarajan, R.	1989	2004	16	27.11	27	1.77	0.49
24	Bhat, S.V.	1987	2011	25	42.37	26	1.7	0.48
25	Deepak, F.L.	2001	2007	7	11.86	25	1.64	0.46
26	Pradeep, T.	1987	1992	9	15.25	25	1.64	0.46
27	Waghmare, U.V.	2005	2013	9	15.25	25	1.64	0.46
28	Mohan Ram, R.A.	1983	1990	8	13.55	24	1.58	0.44
29	Rao, G.R.	1972	1991	20	33.89	23	1.51	0.42
30	Sankar, G.	1983	1996	14	23.72	23	1.51	0.42

31	Lieber, E.	1957	1966	10	16.94	22	1.44	0.41
32	Panchakarla, L.S.	2007	2012	6	10.16	22	1.44	0.41
33	Vaidhyanathan, R.	1999	2004	6	10.16	22	1.44	0.41
34	Yashonath, S.	1981	1995	15	25.42	22	1.44	0.41
35	Ganapathi, L.	1984	1989	6	10.16	21	1.38	0.39
36	Mahendiran, R.	1995	2003	9	15.25	21	1.38	0.39
37	Sen, R.	1994	2000	7	11.86	21	1.38	0.39
38	Voggu, R.	2006	2013	8	13.56	21	1.38	0.39
39	Arulraj, A.	1996	2005	10	16.95	20	1.31	0.37
40	Gundiah, G.	2000	2005	6	10.17	20	1.31	0.37
41	Maitra, U.	2003	2013	11	18.64	20	1.31	0.37
42	Satishkumar, B.C.	1996	2002	7	11.86	20	1.31	0.37
43	Vivekchand, S.R.C.	2002	2009	8	13.56	20	1.31	0.37

Top 50 Highly Journals Preferred of Significant Research Work

S. No.	Journal Name	Country	IF 2013	No. of Papers	Percentage
1	Journal of Solid State Chemistry – Elsevier	USA	2.2	93	6.11
2	Chemical Physics Letters – Elsevier	Netherlands	1.991	92	6.05
3	Solid State Communications – Elsevier	UK	1.698	66	4.33
4	Journal of Materials Chemistry – RSC	UK	6.626	54	3.55
5	Materials Research Bulletin - Journal – Elsevier	USA	1.968	49	3.22
6	Physical Review B - APS	USA	3.664	46	3.02
7	Chemical Communications – RSC	UK	6.718	34	2.23
8	Journal of Physical Chemistry – ACS	USA	2.775	33	2.17
9	Journal of Physics: Condensed Matter – IOP	UK	2.223	31	2.04
10	Journal of Molecular Structure – Elsevier	Netherlands	1.599	29	1.9
11	Chemistry of Materials – ACS	USA	8.535	27	1.77
12	Canadian Journal of Chemistry – NRC	Canada	1.013	27	1.77
13	Physica C - Superconductivity and its Applications – Elsevier	Netherlands	1.11	25	1.64
14	Journal of the American Chemical Society – ACS	USA	11.444.	21	1.38
15	Applied Physics Letters – AIP	USA	3.515	20	1.31

16	Solid State Sciences – Elsevier	Italy	1.679	20	1.31
17	Spectrochimica Acta A – Elsevier	Netherlands	2.129	20	1.31
18	Journal of Chemical Sciences – IAS	India	1.224	19	1.25
19	Journal of Nanoscience and Nanotechnology- ASP	USA	1.339	18	1.18
20	Inorganic Chemistry – ACS	USA	4.794	17	1.11
21	Pramana-Journal of Physics - IAS – Springer	India	0.72	17	1.11
22	Angewandte Chemie International Edition – Wiley	Germany	11.336.	16	1.05
23	Current Science – CSA	India	0.833	16	1.05
24	Journal of the Chemical Society - Chemical Communications – RSC	UK	6.718	16	1.05
25	Journal of Physics C-Solid State Physics – IOP	UK	2.223	16	1.05
26	Transactions of the Faraday Society – RSC	UK	NA	16	1.05
27	Chemistry - A European Journal – Wiley	Germany	5.696	15	0.99
28	Surface Science – Elsevier	Netherlands	1.87	15	0.99
29	Indian Journal of Chemistry Sec A – NISCARE	India	0.628	14	0.92
30	Dalton Transactions – RSC	UK	4.097	13	0.85
31	Journal of Physical Chemistry B – ACS	USA	3.377	13	0.85
32	Journal of the Chemical Society-Faraday Transactions II – RSC	UK	4.097	13	0.85
33	Journal of Physics and Chemistry of Solids – Elsevier	USA	1.594	12	0.79
34	Journal of Materials Research – MRS	USA	1.815	12	0.79
35	ChemPhysChem – Wiley	Germany	3.36	11	0.72
36	Journal of Physical Chemistry C – ACS	USA	4.835	11	0.72
37	Advanced Materials – Wiley	Germany	15.409	10	0.66
38	Pure and Applied Chemistry – IUPAC	USA	3.112	10	0.66
39	European Journal of Solid State and Inorganic Chemistry – Elsevier	Italy	1.679	10	0.66
40	Indian Journal of Chemistry – NISCARE	India	NA	10	0.66
41	Modern Physics Letters B - World Scientific	Singapore	0.687	9	0.59
42	Langmuir – ACS	USA	4.384	9	0.59
43	Accounts of Chemical Research – ACS	USA	24.348	9	0.59
44	Journal of Physics D-Applied Physics - IOP	UK	2.521	9	0.59
45	Journal of Chemical Physics – AIP	USA	3.122	9	0.59
46	Journal of the Chemical Society-Dalton Transactions – RSC	UK	4.097	9	0.59

47	Applied Surface Science – Elsevier	Netherlands	2.538	9	0.59
48	Catalysis Letters – Springer	Netherlands	2.291	9	0.59
49	Proceedings of the Royal Society of London A – RSC	UK	1.998	9	0.59
50	Phase Transitions - T&F	UK	1.044	8	0.52

Publisher wise Distribution of C N R Rao Papers

S. No.	Publisher	No. of Papers	% of Publisher in the Total Publication	No. of Journals	% of the Journals
1	Elsevier (Science Direct)	563	37.01	63	29.03
2	Royal Society of Chemistry (RSC)	203	13.35	23	10.59
3	American Chemical Society (ACS)	169	11.11	20	9.21
4	Wiley	106	6.97	24	11.05
5	Institute of Physics (IOP - Journals)	80	5.26	13	5.99
6	American Physical Society (APS)	51	3.35	2	0.92
7	Indian Academy of Science (IAS)	41	2.69	4	1.84
8	Springer	39	2.56	11	5.07
9	Taylor & Fransis (T&F)	39	2.56	12	5.53
10	American Institute of Physics (AIP)	34	2.23	3	1.38
11	NISCARE	34	2.23	5	2.3
12	NRC Research Press	27	1.77	1	0.46
13	American Scientific Publishers (ASP)	20	1.31	3	1.38
14	Current ScienceJournans (CSJ)	16	1.05	1	0.46
15	Materials Research Society (MRS)	14	0.92	2	0.92
16	World Scientific (WS)	13	0.85	3	1.38
17	International Union of Pure and Applied Chemistry (IUPAC)	10	0.66	1	0.46
18	Royal Society of Publishing (RSP)	9	0.59	1	0.46
19	Nature (NPG)	8	0.52	3	1.38
20	Indian Chemical Society (ICS)	7	0.46	1	0.46
21	Verlag der Zeitschrift fur Naturforschung	6	0.39	1	0.46
22	American Association for the Advancement of Science (AAAS)	4	0.26	1	0.46
23	Proceedings of the National Academy of Sciences (PNAS)	4	0.26	1	0.46

24	Chemical Sciences Journal (CSJ Journals)	3	0.19	1	0.46
25	Society for Applied Spectroscopy (SAS)	3	0.19	1	0.46
26	European Physical Journal (EPJ)	2	0.13	1	0.46
27	Indian Association for the Cultivation of Science (IACS)	2	0.13	1	0.46
28	Agra University	1	0.06	1	0.46
29	Almqvist & Wiksell	1	0.06	1	0.46
30	Annual Reviews	1	0.06	1	0.46
31	Beilstein Institute for the Advancement of Chemical Sciences (BIACS)	1	0.06	1	0.46
32	Hrvatsko kemijsko društvo	1	0.06	1	0.46
33	IEEE Xplore Digital Library	1	0.06	1	0.46
34	InderScience	1	0.06	1	0.46
35	InTech Publication	1	0.06	1	0.46
36	Many Publication	1	0.06	1	0.46
37	Oldenbourg Wissenschaftsverlag GmbH	1	0.06	1	0.46
38	Optics InfoBase	1	0.06	1	0.46
39	Polish Academy of Science	1	0.06	1	0.46
40	Swiss Chemical Society	1	0.06	1	0.46
41	Trans.Tech Pub	1	0.06	1	0.46
	Total	1521	99.84	217	99.93

Top 25 Highly Impact Factor Journals Used in Significant Research Work

S. No.	Journal Name	Country	IF 2013	No. of Papers	Percentage
1	Chemical Reviews – ACS	USA	45.661	2	0.13
2	Nature	UK	42.351	6	0.39
3	Nature Materials	UK	36.425	1	0.06
4	Science – AAAS	USA	31.48	4	0.26
5	Chemical Society Reviews – RSC	UK	30.425	6	0.39
6	Surface Science Reports – Elsevier	Netherlands	24.562	1	0.06
7	Accounts of Chemical Research (ACS	USA	24.348	9	0.59

	Publications)				
8	Nature Chemistry	UK	23.297	1	0.06
9	Nano Today – Elsevier	Netherlands	18.432	1	0.06
10	Energy & Environmental Science, RSC	UK	15.49	1	0.06
11	Advanced Materials – Wiley	Germany	15.409	10	0.65
12	ACS Nano (ACS Publications)	USA	12.033	4	0.26
13	Materials Science & Engineering R-Reports – Elsevier	Switzerland	11.789	1	0.06
14	Journal of the American Chemical Society(ACS)	USA	11.444	21	1.38
15	Angewandte Chemie International Edition – Wiley	Germany	11.336	16	1.05
16	Materials Today - Journal – Elsevier	UK	10.85	1	0.06
17	Advanced Functional Materials - Wiley	Germany	10.4	2	0.13
18	Nano Energy – Elsevier	Netherlands	10.211	1	0.06
19	PNAS : Proceedings of the National Academy of Sciences	USA	9.809	4	0.26
20	Chemical Science – RSC	UK	8.601	2	0.13
21	Chemistry of Materials – ACS	USA	8.535	27	1.77
22	Progress in Solid State Chemistry – Elsevier	UK	8.182	2	0.13
23	Annual Review of Analytical Chemistry	USA	7.814	1	0.06
24	Physical Review Letters – APS	USA	7.728	5	0.32
25	Small - Wiley	Germany	7.514	5	0.32

Top 20 Research Papers Received Highly Citation of Significant Research Works Based on Google Scholar

S. No.	Year	Title	Journal Name	Publisher	Impact Fcator 2013	Citation by Google Scholar
1	2009	"Graphene: A New Two-Dimensional Nanomaterial".	Angewandte Chemie International Edition	Wiley	11.336.	1785
2	2004	"Metal Carboxylates with Open Architectures".	Angewandte Chemie International Edition	Wiley	11.336.	1704
3	2003	"Inorganic Nanowires".	Progress in Solid State Chemistry	Elsevier	8.182	725
4	2001	"Nanotubes".	ChemPhysChem	Wiley	3.36	667
5	2006	"Ferromagnetism as a Universal Feature of Nanoparticles of the Otherwise Nonmagnetic Oxides".	Physical Review B	APS	3.664	646
6	2009	"Synthesis, Structure, and Properties of Boron- and Nitrogen-Doped Graphene".	Advanced Materials	Wiley	15.409	606
7	2000	"Metal Nanoparticles and Their Assemblies".	Chemical Society Reviews	RSC	30.425.	592
8	1996	"Structure, Electron-Transport Properties, and Giant Magneto- resistance of Hole-Doped $LaMnO_3$ Systems".	Physical Review B	APS	3.664	513
9	2002	"Size-Dependent Chemistry: Properties of Nanocrystals".	Chemistry - A European Journal	Wiley	5.696	512
10	2010	"MoS_2 and WS_2 Analogues of Graphene".	Angewandte Chemie International Edition	Wiley	11.336.	484
11	2008	"Graphene-Based Electrochemical Supercapacitors".	Journal of Chemical Sciences	IAS	1.224	474
12	2006	"Structural Diversity and Chemical Trends in Hybrid Inorganic-Organic Framework Materials".	Chemical Communications	RSC	6.718	460
13	2001	"Science and Technology of Nanomaterials: Current Status and Future Prospects".	Journal of Materials Chemistry	RSC	6.626	443
14	1996	"Effect of Particle Size on the Giant Magnetoresistance of $La_{0.7}Ca_{0.3}MnO_3$".	Applied Physics Letters	AIP	3.515	393
15	1997	"Giant Magnetoresistance and Related Properties of Rare Earth Manganates and Related Systems".	Solid State Ionics	Elsevier	2.112	360

16	1996	"Giant Magnetoresistance and Related Properties of Rare-Earth Manganates and Other Oxide Systems".	Chemistry of Materials	ACS	8.535	360
17	1997	"Carbon Nanotubes by the Metallocene Route".	Chemical Physics Letters	Elsevier	1.991	346
18	2009	"Graphene, the New Nanocarbon".	Journal of Materials Chemistry	RSC	6.626	334
19	2001	"Aufbau Principle of Complex Open-Framework Structures of Metal Phosphates with Different Dimensionalities".	Accounts of Chemical Research	ACS	24.348	331
20	2000	"Y-Junction Carbon Nanotubes".	Applied Physics Letters	AIP	3.515	327

Conclusion

This paper based on the research output of C.N. R. Rao publications during the period from 1959 to 2013. C.N.R. Rao has published 1521 research papers in chemistry and basic sciences with an average of 25.77 papers per year. The percentage of collaborative work of the Rao has found to be very high as 82.11% collaborative works with 5416 collaborators with whom he work in various organizations. 17.88% of his total publications were published as a main author. His highest annual growth rate was 1600% in the year 1966 and highly productive year was 2000 in which he published 54 papers. He published his papers in mostly preferred international journals with 32.67% related to USA published journals followed by UK with 29.19%. He published 7.03% of papers in Indian journals. He has received several awards and honors to his credit in recognition of his significant contribution including the Bharat Ratna in 2014. Still he is working at the age of 82 which reflects the kind of involvement and dedication towards his research.

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